

# **CHAPTER 2: HYDROLOGY**

## **BACKGROUND**

United States Geological Survey (USGS) flow records for the San Juan River begin in 1911, but are not consistent or complete until about 1929. By this time substantial irrigation development had occurred. While the pre-Navajo Dam hydrology is natural in shape, it is depleted in volume by about 16 percent from natural conditions due to this irrigation development, with most of the depletion coming during the summer months. Since the depletion prior to Navajo Dam was relatively small and the flow was not regulated by major storage reservoirs, the conditions during the pre-dam period (1929-1961) are used to judge effects of later development and the value of future modification of the hydrology for the benefit of the endangered fishes.

Daily flow data recorded by the USGS from 1929 through the present are available for the key points on the San Juan River. These data have been used to analyze the 2000 hydrology and compare the statistics to other years. The foundation of comparison are the flow statistics in the SJRIP Flow Recommendation Report (Holden, 1999).

## **METHODS**

Beginning in 1999, the operating rules recommended in the Flow Recommendation Report have been employed by Reclamation as far as restrictions would allow. Presently, the only restriction is to the minimum release from Navajo Dam, which cannot fall below 500 cfs until an Environmental Impact Statement (EIS) is completed. USGS gage records were used to assess the resulting hydrograph at Archuleta, Farmington, Shiprock, Four Corners and Bluff.

For each release year, the operating rules are evaluated utilizing the anticipated water supply and the release criteria set. The design release pattern and the actual releases are compared. The statistics of each year are computed and the flow recommendation conditions that were met indicated.

## **RESULTS**

Research releases from Navajo Dam were made every year from 1992 through 1998 (1991 was a control year with no modification to the release) to augment the unregulated flows from the Animas River and provide peak spring runoff flows mimicking a natural hydrograph in the San Juan River below Farmington, NM. Beginning in 1999, the operating rules presented in the Flow Recommendation Report were implemented. August and September of 1999 were very wet with flows peaking at over 8000 cfs at the Four Corners Gage. Using the storm event day algorithm presented in Chapter 7 of the SJRIP Flow Recommendation Report shows 1999 to be a perturbing year. Based on the Navajo operation rule tree, this would result in a release of 114,000 ac-ft. However, the high, late season flows cleaned out key backwater habitat areas and so it was determined that there was no perturbation and hence no flushing release was required in 2000.

Table 2.1 describes the nature of the release each year since 1991. The volume of water released in excess of an assumed base release of 600 cfs normally required to meet downstream demands is also shown. In 2000 over 61,000 ac-ft was released although no release was called for. As can be seen in Table 2.1 there was an 8-day ramp up, one day at peak and a 7 day ramp down. This was done to meet a Navajo Reservoir end of June target elevation of 6072 feet. Reclamation was concerned about a repeat of the 1999 flows and the end of June target of 6072 feet was the result of conservative flood control measures in conjunction with monitoring requirements at the dam.

Table 2.2 compares the flow statistics from 2000 to those of the 1992-1999 period for each category identified in the Flow Recommendation Report. Also indicated are the desired conditions that were met. With the exception of average base flow and in July, all flow conditions were met.

**Table 2.1. Summary of Navajo Dam release hydrograph characteristics since the beginning of the research period, 1992 to 2000.**

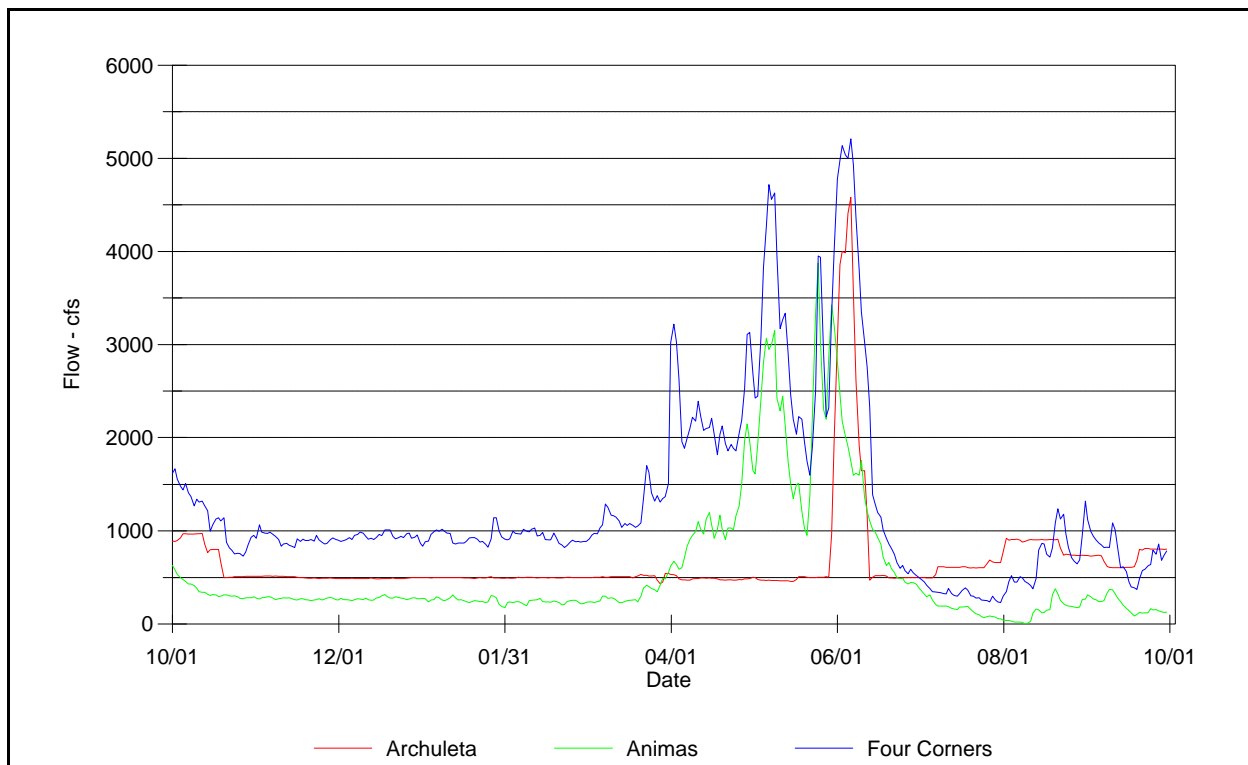
YEAR	ASCENDING LIMB	PEAK	DESCENDING LIMB	MATCHED ANIMAS RIVER PEAK	VOLUME ABOVE 600 CFS BASE - AF
1992	6 weeks starting April 13	2 weeks at 4,500 cfs	4 weeks ending July 15	Yes	409,740
1993	Starting March 1, rapid increase to 4,500 (compare with 1987)	split peak, 45 days at 4,500 cfs, 7 days at 4,500 cfs	4 weeks ending July 13	No	773,820
1994	4 weeks starting April 23	3 weeks at 4,500 cfs	6 weeks ending July 28	Yes	486,620
1995	3 weeks at 2,000 cfs in March, ramp to 4,500 over 6 weeks starting April 1	3 weeks at 5,000 cfs	4 weeks ending July 14 (summer flow increased by 200 cfs)	Yes	675,810
1996	1 week starting May 27	3 weeks at 2,500 cfs	1 week ending June 29	No	100,320
1997	3 weeks at 2,000 cfs in March, return to 600-cfs base for 31 days, 10 days starting May 12	2 weeks at 5,000 cfs	6 weeks ending July 16	Yes	433,580
1998	30 days starting April 23	3 weeks at 5,000 cfs	1 week ending June 18	Yes	340,850
1999	9 days starting May 24	8 days at 5000 cfs	9 days ending June 18	No	166,189
2000	8 days starting May 30	1 day at 4580	7 days ending June 13	No	61,484

The 2000 hydrographs for the San Juan River at Archuleta (release hydrograph) and at Four Corners are presented in Figure 2.1. The hydrographs at Four Corners for these years appear in Figures 2.2 and 2.3. The flow statistics that apply to these hydrographs appear in Table 2.3. The Four Corners gage is considered the most representative gage for the habitat range and is used in all correlations reported here.

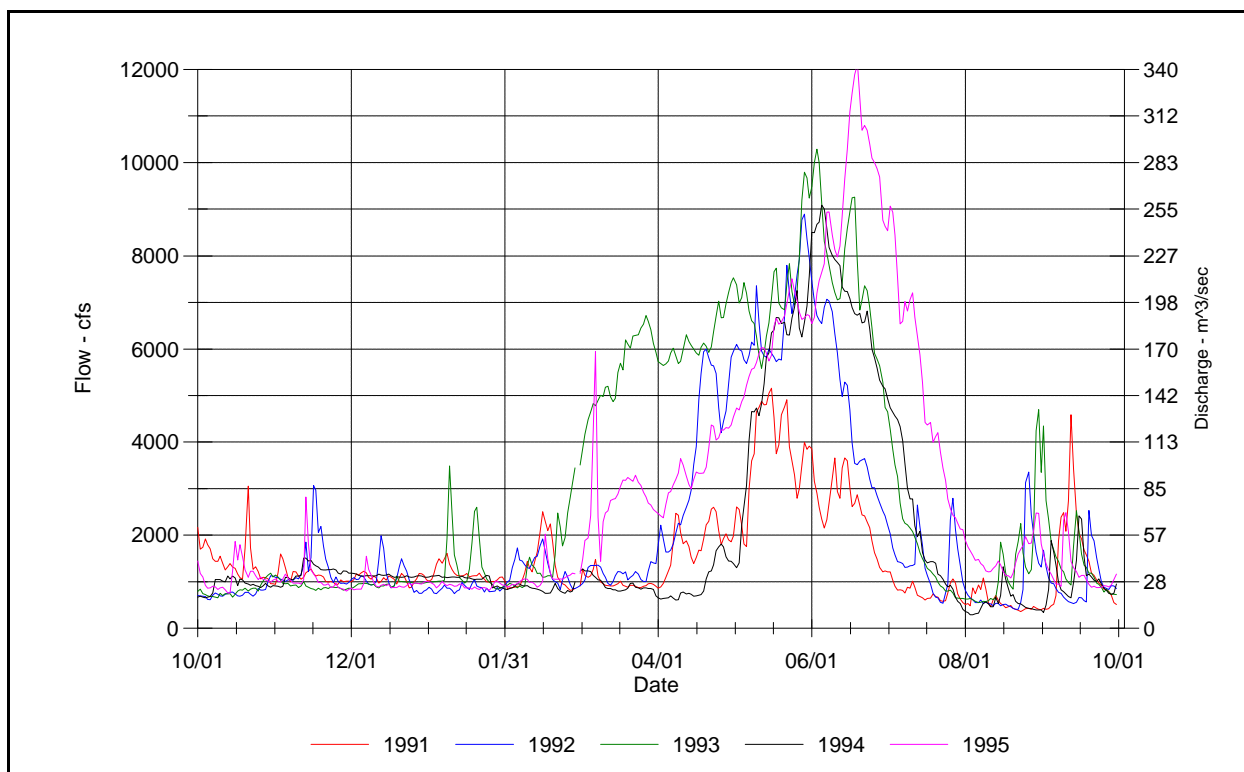
**Table 2.2. Flow Statistics met in each year**

Flow Condition	Std	1993	1994	1995	1996	1997	1998	1999	2000
Days at 10,000 cfs or more	5	1	0	<b>11</b>	0	<b>10</b>	0	0	0
Days at 8,000 cfs or more	10	<b>16</b>	<b>13</b>	<b>27</b>	0	<b>33</b>	2	0	0
Days at 5,000 cfs or more	21	<b>109</b>	<b>49</b>	<b>72</b>	0	<b>50</b>	<b>34</b>	<b>29</b>	3
Days at 2,500 cfs or more	10	<b>128</b>	<b>67</b>	<b>135</b>	<b>36</b>	<b>100</b>	<b>65</b>	<b>70</b>	<b>37</b>
Yrs w/o meeting 10,000cfs	10	<b>7</b>	<b>8</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>
Yrs w/o meeting 8,000 cfs	6	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>
Yrs w/o meeting 5,000 cfs	4	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>
Yrs w/o meeting 2,500 cfs	2	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>

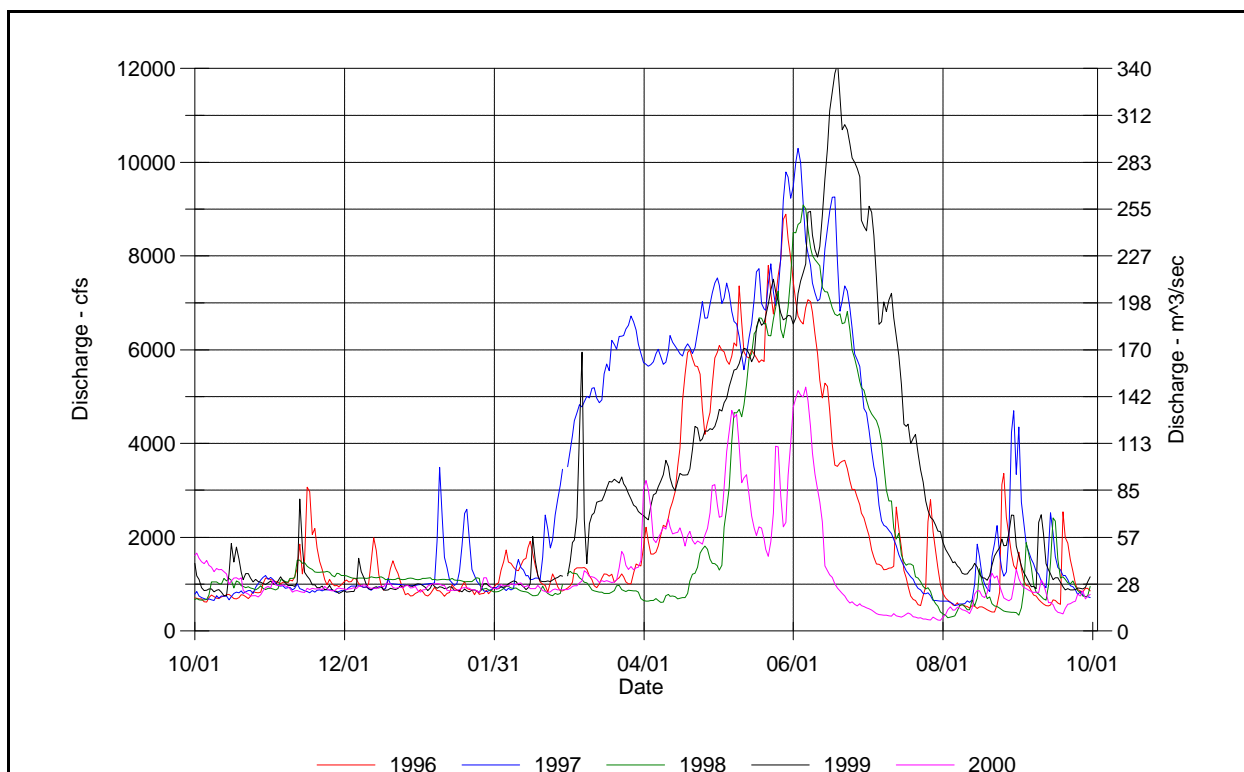
Note: Values in Bold are those that meet or exceed the minimum standard



**Figure 2.1. 2000 hydrographs for Animas River at Farmington, San Juan River at Archuleta and Four Corners.**



**Figure 2.2. Hydrographs for the San Juan River at Four Corners 1991 - 1995**



**Figure 2.3. Hydrographs for the San Juan River at Four Corners 1996 - 2000**

**Table 2.3. Summary of flows for the research (1991-1998) and monitoring (1999-2000) periods, San Juan River at Four Corners, New Mexico.**

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
San Juan River at Four Corners, New Mexico										
Peak Runoff-cfs	5,160	8,900	10,300	10,000	12,100	3,540	11,900	8,580	8,030	5210
Runoff(Mar-Jul)-af	599,459	1,074,795	1,714,328	1,039,601	1,624,927	431,913	1,338,539	931,106	876,846	548,424
Runoff(total annual)-af	1,086,676	1,512,795	2,216,819	1,448,893	2,102,228	815,795	1,844,019	1,401,536	1,901,803	928,807
Peak Date	16-May	29-May	03-Jun	05-Jun	19-Jun	18-May	04-Jun	04-Jun	03-Jun	06-Jun
Days>10,000	0	0	1	0	11	0	10	0	0	0
Days>8,000	0	3	16	13	27	0	33	2	0	0
Days>5,000	2	54	109	49	72	0	50	34	29	3
Days>2,500	46	81	128	67	135	36	100	65	70	37
Ave. Daily Flow for month										
October	1,449	769	827	941	1,109	1,091	1,276	1,404	1,533	1,141
November	1,127	1,356	911	1,210	1,077	1,139	883	1,175	1,494	910
December	1,080	1,088	957	1,105	960	1,088	702	1,154	1,031	940
January	1,173	859	1,358	1,050	918	785	789	1,208	947	935
February	1,289	1,298	1,511	781	1,076	899	690	1,239	976	931
March	995	1,173	5,463	967	2,782	766	2,255	1,267	969	1,186
April	1,810	3,723	6,188	1,028	3,478	607	2,529	1,910	1,174	2,263
May	3,739	6,634	7,298	5,251	6,119	2,150	6,000	5,831	3,439	2,995
June	2,580	4,844	7,701	7,836	9,367	2,925	8,514	4,542	5,986	2,293
July	801	1,444	1,776	2,170	5,187	715	2,904	1,802	2,925	330
August	556	927	1,348	552	1,564	492	2,310	1,073	6,135	708
September	1,441	997		1,142	1,193	891	2,365	574	4,852	733
Uniqueness		Control	early ave.	early ascent	late ave.	late peak	dry	narrow runoff	early ave.	dry
			storm @ spawn					storm @ spawn	storm @ spawn	